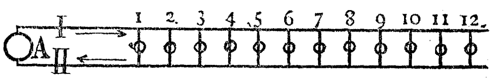
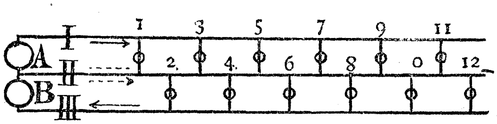
EDISON'S THREE-WIRE SYSTEM OF DISTRIBUTION.

THE three-wire or multiplex system of distributing currents for electric lighting over large areas, as devised and used by Edison, is highly ingenious, and effective in reducing the necessary size of the large copper conductors. The size of the conductor must be proportioned to the maximum number of lamps which it will ordinarily supply. This number being given, the size should be such that the resistance of the metallic part shall bear a fixed ratio to that of the lamp part of the circuit; and the value of this ratio will be determined by the condition that the additional running expense due to the resistance of the conductor shall equal the interest on its first cost, so far as this depends upon its cross-section.

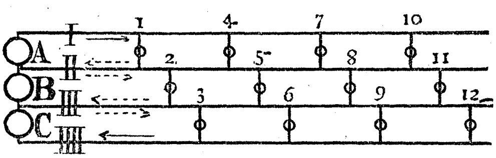
In the two-wire system, *A* is the dynamo, which we will suppose to keep up a difference of potential of a hundred volts between the conductors I and II. Across these are bridged twelve lamps of equal resistance, representing what would be, in practice, several hundred dwellings, factories, churches, theatres, etc.



TWO-WIRE SYSTEM.



THREE-WIRE SYSTEM.



FOUR-WIRE SYSTEM.

The next figure shows Edison's three-wire modification of this. *A* and *B* are two dynamos coupled in series, with conductors I, II, and III leading out as shown. As *A* and *B* each keep up a hundred volts, as before, the difference of potential between I and III will be two hundred volts. The twelve lamps are now, however, equally divided between the circuits I–II and II–III, connected as shown. If the resistance of the six odd-numbered lamps, 1–11, exactly equals that of the six even-numbered, 2–12, and if *A* and *B* keep up the same difference of potential, no current will flow in II, between the dynamos and where the first lamp joins it. Suppose II to be cut, there will then be a single circuit through *A* and *B*, I and III, and the twelve lamps, as shown, with a difference of two hundred volts in I and III. The resistance of the twelve lamps, as now arranged, will be four times what it was before; and hence only one-half as much current will flow through I and III. But each of the lamps will get just as much as before, and will shine the same. The conductors I and III, since the resistance is now four times as great, need only be one-fourth as heavy, according to our adopted principle. This is also proper as regards heating-effect in them, which, proportional to the square of the current, is now only one-fourth what it was before.

If this were all that was needed, we should now have the same amount of lighting done, and the conducting-mains, which are the most expensive part of the plant, of only one-fourth their size and cost in the two-wire system, and with only the additional expense of another dynamo. Moreover, since the current is only one-half as much, these two dynamos, though giving the same potential as before, can be smaller. But on account of the difficulty in keeping an exact balance in the two sets of lamps, especially about the time of lighting up at twilight, it is necessary to introduce the third conductor from between the two dynamos, and then neither circuit can be exposed to a difference of potential greater than either dynamo is generating. Also, if the balance is not kept, a current through II, and a galvanometer, shows on which side the lamp-resistance or the dynamo-potential is in excess; and Edison restores the balance by variable resistances in the circuits of the field-magnets, or, in some cases, by bringing an extra conductor from one or two large buildings, like factories, theatres, etc., when near by, so that they can, at will, be thrown into either circuit from the central station.

This middle wire need not, for most purposes, be so large as the other two; but, in the case of a breakdown of I or III, it will have to do equal work with the other, so that it is safer, simpler, and better to make them all of the same size. The cost, then, of conductors, is that of three wires, each of one-fourth the section of the two in the first case, or $\frac{3}{2} \cdot \frac{1}{4} =$ .375, or a saving of sixty-two and a half per cent.

The four-wire system shows a still further reduction of expense. The law on which this percentage of economy proceeds, as far as cost of conductors is concerned, may be shown as follows, in units of the cost of the two-wire system: —

For 2 wires, we have, $\frac{2}{2}\left(\frac{1}{1}\right)^2 = 1.000$
" 3 " " " $\frac{3}{2}\left(\frac{1}{2}\right)^2 = .375$
" 4 " " " $\frac{4}{2}\left(\frac{1}{3}\right)^2 = .222$
" 5 " " " $\frac{5}{2}\left(\frac{1}{4}\right)^2 = .156$
" 6 " " " $\frac{6}{2}\left(\frac{1}{5}\right)^2 = .120$

A limit of economy or practicability, however, will soon be reached in the increased number of dynamos, the complexity of the system, and especially in keeping up an approximate balance between so many circuits. In practice, probably, the three-wire system, with its saving of .625 of the cost of the two-wire, will be found all-sufficient; except, perhaps, in the case of a long main through a large scattering district, when the four- or five-wire plan might be preferable.

One other advantage, available in all these systems

over the two-wire plan, is, that if needed for purposes of driving motors, or for large street-lamps of higher resistance, a potential twice as high as the ordinary one is very simply available by connecting across from I to III, or three times as high from I to IV in the four-wire plan, etc.; and, no matter what the amount of such employment, it will not disturb the balance of the intermediate lower potential circuits.

H. M. Paul.

ZOÖLOGICAL RESEARCHES OF THE SCOTTISH FISHERY BOARD.

The Scottish fishery board has for its principal function the administration of public matters relating to the fisheries of Scotland; but since its reconstitution in 1881 it has been endeavoring to perform some of the functions so successfully exercised by the U. S. commission of fish and fisheries. It has recently published its report for the year 1883, the second annual report since its reconstitution. In the general report, a short introduction is followed by a chapter on the herring. The first part of this consists of a summary of inquiries into the natural history of the herring, carried out before the year 1882; to this succeeds a summary of the history and results of similar work done in foreign countries; and, finally, there is an account of the researches undertaken by the board since its reconstitution. The rest of the report is taken up with statistics of the various fisheries, and a few paragraphs on the salmon-fishing.

The remaining and of course much the larger portion of the volume is devoted to the various appendices, in which fuller details are given on matters discussed in the general report. Of these, Appendix F describes the investigations carried out at the instance of the board, while Appendix G is Mr. Young's report on the salmon-fisheries.

The biology of the herring, of course, occupies a prominent place in the volume; and in its discussion there is a tendency to optimistic assumptions, which are not in accord with the true spirit of research. For example: the board, or its scientific committee, proposes in the present autumn to deposit, on some of the inshore banks in the Moray Firth, some millions of fertilized herring-eggs; and then, if next year the said bank is visited by a shoal of comparatively small herring, it will conclude, 1°, that they are the produce of the eggs deposited this year; 2°, that herring, like salmon, when about to spawn, instinctively seek their birthplace; 3°, that the migration of herring is limited, and that, in course of time, special varieties of herring may have been formed at different parts of the coast; and 4°, what is of even more importance, that when any particular spawning-ground is deserted, the fishing may be restored without waiting till accident brings another shoal. Investigation would be a very simple matter, if every experiment were as fruitful in inferences as this. The board will have to prove, in the first place, that the herrings, if it finds them next year, are the produce of the eggs it has laid down. He is a wise herring-breeder that knows his own herrings in the open sea.

Professor Ewart's essay on the natural history of the herring forms No. iv. of this appendix. It is, for the most part, an abstract of a paper read by him before the Royal society of London, on the spawning of the herring, and the examination of a spawning-bed at Ballantrae, on the west coast of Scotland. Professor Ewart observed for the first time the spawning and fertilization of herring-eggs in an aquarium. The process, as he describes it, is probably the same, or nearly, as that which takes place in the sea. But it would have been more satisfactory, if, when he had the opportunity, he had observed the behavior of a number of male and female herrings in the same tank. In his experiment there was but a single female herring. The discussion of other problems connected with the life-history of the herring is not very luminous. The author concludes that herring have come to spawn in spring and autumn because the food of the young fry is more abundant at those seasons than at others; but he has no evidence to show that minute pelagic animals are less abundant at a given place in summer than in spring and autumn. A quantitative investigation of the pelagic life at a given spot throughout the year has not yet been carried out, and such a research would be very valuable.

The report on the sprat-fishing, by Mr. Duncan Matthews, contains a record of much good and interesting work, and raises a question of general interest in marine biology. A certain proportion of young herring are killed with the sprats in the firths of Scotland, and herring-fishers believe that this injures their industry. This contention does not seem very important, after such a season as the last, when herrings were so plentiful off the east coast of Scotland that it was almost impossible to find a market for them. But it is of interest to note the difficulty of deciding whether the abundance of a species depends more on the variations in its food-supply than on the attacks of its enemies, or *vice versa.* It is possible, in the case of the herring, that the destruction caused by all its enemies, including man, is insignificant in comparison to its breeding-powers, and that the number which reaches maturity depends entirely on the amount of food available.

PSEUDO-SCIENCE.

The true theory of the sun. By Thomas Bassnett. New York, *Putnam's*, 1884. 41+263 p., illustr., 1 pl. 8°.

We nowhere find in this volume a systematic attempt to arrive at legitimate deductions from all the collected work of observational astronomy and meteorology; but page after page is devoted to the author's baseless speculations, and to the details of such of his own isolated observations as serve to confirm these speculations, while the labors of others, not condu-